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ABSTRACT

A study was conducted to replicate partially John Gould's study using more advanced machines and editors, and to test several of Colette Daiute's hypotheses about writing with the computer. Gould's study indicated that expert writers using text editors required 50% more time to compose on text editors than on hard copy, and the extra time did not improve the writing. Colette Daiute hypothesizes that the computer's speed and ease in editing will help writers to produce more text, that the blinking cursor will stimulate an audience and prompt the writer to consider the reader's needs and to keep writing, and that the machine's speed and ease of editing help to destroy writing blocks. The 15 subjects--faculty, administrators, and system designers from Carnegie-Mellon University--were experienced writers, and had several years of computer experience. Each wrote one letter on each of four topics, in a hard copy condition and three computer conditions. In two of the computer conditions, writers used "Andrew," an advanced computing system and related software being developed at the Information Technology Center as a joint venture of Carnegie-Mellon University and IBM, while the third used the IBM PC and the text editor MINCE. Three quantitative measures were collected and analyzed: time to compose the letter, total words produced, and words produced per minute. The results indicated that writers at the advanced work station produced more texts than in the pen and paper condition, in contrast to the machine Gould tested, and produced better text than in the PC condition. The results suggest that some machines can help people write more and better, but some machines may also make them write more poorly. (HTH)

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CDC Technical Report No. 16

Pen and Paper vs. the Machine: Writers Composing in Hard Copy and Computer Conditions

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February 1986

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Pen and Paper vs. the Machine:

Writers Composing in Hard Copy and Computer Conditions

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Enthusiasm in language education for using computers to write and to teach writing has been, and continues to be, strong. Claims are often made that the computer lessens the tediousness of writing, that computers free the writer from mundane tasks, that computers allow writers to focus on content and meaning, and that computers encourage revision. It is assumed that the computer's strengths--speed and vast memory capacity--somehow help the writer, and that the result is more and better writing.

For instance, Colette Daiute, in a 1983 *College Composition and Communication* article, outlines some of the physical and psychological constraints that she believes computers can help overcome. Specifically, she claims that the computer's speed and ease in editing will help writers to produce more text, that the blinking cursor will simulate an audience and prompt the writer to consider the reader's needs and to "keep writing," and that the machine's speed and ease of editing helps to destroy writing blocks.

However, John Gould in his important 1980 study, found that expert writers using text editors required 50% more time to compose on text editors than on hard copy. Further, this extra time did not lead to qualitatively better writing; there was little difference in quality between letters produced on text-editors and those produced on paper. Although computers may aid writers in some ways, these effects did not show up in Gould's study as longer or better writing.

In the intervening years since Gould's study, however, technological advances have improved the usability and power of text-editors and the quality of computer display. Possibly these design advances have made writing on the computer more efficient and the problems Gould found have been bypassed with the advent of faster machines, screen-oriented editors, and ergonomically designed workstations and displays.

The purpose of this study was two-fold: first, it attempts to partially replicate Gould's experiment, using more advanced machines and editors. Second, it tests several of Daiute's hypotheses about writing with the computer. Specifically, that computers help writers produce more text, produce text faster, and--an indirect claim--that computers help writers write *better*. (Note: Daiute claims that computers help writes produce more well-developed ideas, write in a more "natural linguistic style," and concentrate their efforts on "the logic, organization, and clarity of the piece."

Presumably this facilitation would lead to writing of better quality.)

Subjects: The fifteen subjects were experienced writers--faculty, administrators and system designers from Carnegie-Mellon University. The 11 men and four women ranged in ages from 23 to 42. All of the participants had had at least several years of computer experience, and all worked daily or almost daily on the machines on which they were tested.

Tasks: Participants were instructed to "produce a letter of quality as quickly as possible" on one of these topics:

> Please write a letter to your niece or nephew (real or imagined) who is contemplating coming to Carnegie-Mellon University in the fall. Convince your niece or nephew either **to** attend or **not** to attend C-MU.
>
> Please write a letter to the National Teachers Council nominating a teacher that you have had or have known, past or present, for the NTC's "Outstanding Teacher" award.
>
> Please write a letter to the *Tartan* [the campus newspaper] suggesting a wise or interesting use of a recent anonymous gift of $1 million to the University.
>
> Please write a letter to a high school friend who is contemplating moving to Pittsburgh to take a job. Convince your friend either **to** move to Pittsburgh or **not** to move to Pittsburgh.

The participants wrote the letters in two sessions--two letters the first day, and two letters the second day. Topic and order were counterbalanced across conditions.

Conditions: The participants wrote letters in a hard copy condition and in three computer conditions. In two of the computer conditions writers wrote using "Andrew," an advanced computing system and related
software being developed at the Information Technology Center as a joint venture of Carnegie-Mellon University and IBM (Morris, et al, 1986).

The advanced workstation has a large, bit-mapped, high-resolution display, and a mouse. The text-editor was developed at the ITC and based on EMACS. Placement of the cursor for editing the text is done by pointing the mouse and clicking the mouse button. Writers move through the document by pointing the mouse and clicking in a scroll bar region. For cutting text, writers used either a delete key or a menu option; pasting was also done via a menu. In one condition the window used for writing was 9 1/2 inches wide and 10 1/2 inches long. The other advanced workstation condition differed only in the size of the screen: it was 9 1/2 inches wide and 6 1/2 inches long, the size of a standard pc or terminal display.

In the other computer condition, writers used an IBM-PC and the text-editor MINCE, also based on EMACS. The pc had a 9 1/2 inch by 6 1/2 inch screen and a CRT display. Moving the cursor, moving through the document, and editing are done with control-keys. In the pen-and-paper condition writers used 8 1/2 by 11 inch ruled paper and their choice of a felt-tip or ball-point pen. When writing in the computer conditions, writers were not allowed to use pen and paper notes, not to get a printout of their texts.

The salient differences between the computers are summarized in the table below.

	workstation	pc
Machine		
speed	16 kilo-baud	9600 baud
resolution	bit-mapped black on gray	CRT green on black
screen size	9 1/2 by 10 1/2 50 lines by 90 characters	9 1/2 by 6 1/2 24 lines by 88 characters
Editor (Note: all computer conditions used display editors.)		
text advancement method	scroll bar and mouse	control-keys
cursor movement	mouse/pointer	control-keys
editing--deleting, cut/pst	mouse/menu; delete key	control-keys

Analyses

Three quantitative measures were collected and analyzed: time to compose the letter, total words produced, and words produced per minute. Because there was no significant difference in any measure between the workstation large and small conditions, these data were collapsed into a single workstation condition, Condition 1. The pc condition is Condition 2, and the pen-and-paper condition, 3. Scores were normalized for topic and order effect. Means for time to compose are shown below.

Time to compose was longest in the advanced workstation condition, and shortest in the hard copy condition. These differences were significant at the .02 level by analysis of variance. Neuman-Keuls analysis shows this variance accounted for by a significant ($< .05$) difference between the workstation and paper conditions.

Time

Cond. 1, workstation	17.40 minutes
Cond. 2, pc	15.12 minutes
Cond. 3, pen-and-paper	13.43 minutes

The second measure--number of words produced--also showed a significant difference, with the highest mean number of words in the advanced workstation condition, and the smallest mean number of words in the hard copy condition. These differences are significant at the $< .01$ level by analysis of variance. Neuman-Keuls shows the variance to be accounted for by a significant difference between conditions 1 and 3. Condition 2 was not significantly different from either of the other conditions.

Total Words

Cond. 1, workstation	352.79 words
Cond. 2, pc	291.62 words
Cond. 3, pen-and-paper	264.05 words

The words-per-minute measure shows no significant difference between conditions--workstation 20.17 wpm; pc, 21.00 wpm; pen and paper, 20.94 wpm.

In addition, two measures of writing quality were collected. Independent readers (English teachers with at least five years experience teaching writing) rated each subject's letters using a forced quartile split. The letters received scores for *content*--quality of ideas--and for *mechanics*--sentence- and word level-correctness. Agreement between two raters was 80%. When raters scores were more than one quartile different, a third reader read and rated the letters. Again, because there were no discernable difference between the two workstation conditions, the data was collapsed into a single workstation condition. With possible scores ranging from 2 (low) to 8 (high), mean scores for each condition were:

Content

Cond. 1, workstation	5.96
Cond. 2, pc	4.0
Cond. 3, pen-and-paper	5.13

Mechanics

Cond. 1, workstation	5.23
Cond. 2, pc	4.26
Cond. 3, pen-and-paper	5.67

The content measure differences are significant at the .02 level by analysis of variance. Neuman Keuls analysis shows that the texts produced in the pc condition were significantly poorer ($< .05$) than those produced in the advanced workstation condition. The differences between the pc condition and the hard copy condition were just short of significant. Although the differences in mechanics scores are not significant, the mean scores for the PC Condition are again the lowest.

In addition, the difference in *total quality* scores was significant at the .02 level by analysis of variance. Mean total scores--sum of content and mechanics scores--were:

Total

Cond. 1, workstation	11.20
Cond. 2, pc	8.26
Cond. 3, pen-and-paper	10.89

Neuman Keuls analysis shows again, that the pc condition was significantly different ($< .05$) from the advanced workstation condition and from the hard copy condition.

Discussion

The advanced workstation fares well in each of these analyses: in this condition, writers produced *more text* than in the pen and paper condition and produced *better text* than in the pc condition. I will first discuss these results in light of Gould's 1980 findings, focusing on differences in results on the computers and on differences in the computers themselves. I will then look specifically at two trends in the results of this study and discuss implications.

Although not a replication of Gould's study, this experiment nonetheless has several salient similarities. The number and kind of subjects were similar: Gould used ten IBM research professionals, I used 15 systems designers , administrators, and faculty. Like Gould's subjects, these people were experienced users of text editors and used a computer for most of their daily personal and professional writing. The task for this study--writing persuasive letters-- was similar to the "competitive letters" Gould's subjects wrote.

There were, however, some important differences. Gould collected process measures via videotape and a time-stamp program for computer activity; he included secretarial time for typing of written letters; and he included several other tasks along with the persuasive letter writing. I focused specifically on the quantity and quality measure described above--and omitted the analysis of secretarial time for typing--in order to specifically address how texts written on computers compare to handwritten letters by the same writers. In the following comparison of my results with Gould's, I will discuss only his "competitive letter" task, although the results for the other categories--messages, routine letters, and map letters--were comparable.

In addition, the machines and editors used for the study were different from Gould's, reflecting at least four years advancement in computer design. The three computer conditions, using two different machines, are described above. Note that the machines in this study used screen editors rather than line editors, used in the earlier studies, that the resolution and screen size of the machines Gould used are comparable to the personal computer condition in this study, and--most important--that the subjects in this study used no formatting commands in any computer condition.

The mean composition times for Gould's writers were 30.6 minutes in the computer condition and 19.7 minutes for the paper condition. Similarly, the writers in this study also took longer to compose their letters in the computer conditions--they were fastest in the hard copy condition--and although not as striking as Gould's, the differences were still significant. The faster composition time can be interpreted in two ways--perhaps writers are more efficient with paper and pen than with computer, or possibly they are doing a more thorough job on the computer. The latter explanation gains credence in the total words produced analysis discussed below.

The mean number of words that Gould's subjects produced were similar in the two conditions--250.7 words in the computer condition and 242.4 words in the paper condition. In this study, there was a significant difference in total words produced with the pen and paper condition falling well below the advanced workstation condition. Alternatively, however, Gould found that writers produced significantly more words per minute using pen and paper, while this study shows no significant difference between conditions in words written per minute.

There are at least two possible contributing factors that would explain the differences between these quantitative results and Gould's. .First, the writers in this study did

NOT use formatting commands--they simply entered text. Gould originally hypothesized that longer times (and fewer words per minute) might be the result of the extra cognitive load of remembering and issuing formatting commands. This seems a viable explanation for the differences in time and words per minute.

However, this explanation does not explain the longer texts produced in this study by writers when using advanced workstations rather than pc or pen and paper. It seems that while writers are writing as fast with both of the computers tested here as they are with paper, they are writing *for longer periods of time* and producing *longer texts* with the advanced workstation.

Therefore, in addition to the absence of formatting commands, another contributing factor for the difference in these results and Goulds's is the machines and editors themselves. (Refer to Table 1 for a summary of machine differences.) Possibly the better resolution of the advanced display lessened fatigue and so the writers wrote longer. Apparently, screen size is not a crucial variable in this task, since subjects performed comparably with both large screen and small screen advanced workstations. (Note: Although our own earlier research showed an advantage for large screens over small screens in performance on writing-related reading tasks, there is no similar difference evidenced here. However, these texts were much shorter--around 300 words--than the 1500 word texts used in the reading studies. In addition, these experienced writers may have developed strategies to compensate for constraints in reading on the computer. See Haas and Hayes, 1986, for a discussion of these reading results.)

The type of editor used in this study--Mince and EditText, both based on EMACS--probably contributed to these subjects' better performance than those of Gould's. The editors used in this study--both on the pc and on the advanced workstation--were display editors, while Gould's earlier experiment tested line editors. Teresa Roberts (1979; Roberts and Moran, 1982; both cited in Card, Moran, and Newell, 1983) found that display editors were both easier to learn and faster to use than line editors like the one Gould was testing.

Apparently, design improvements have made a difference, at least in writing tasks like this with experienced writer/users: even the pc (with poor resolution and small screen and without mouse) shows an advantage over the machine and editor that Gould used five years ago. Writers in Gould's computer condition were less efficient, taking longer to compose their letters and producing letters more slowly. In spite of this however, the writers generated letters that were about the same length as the pen and paper letters. However, in this study, writers using the pc--with a screen-oriented editor but a similar display--were as efficient as with hard copy: subjects produced as many words per minute as with paper (an improvement over the earlier results) spent about as much time writing, and produced about the same length of letters with paper and with pc.

Moreover, the advanced machines were more efficient than the pen and paper condition. Although the words per minute were not significantly different, writers produced more words in the advanced workstation conditions than they did in the paper condition and the time that writers spent writing was significantly longer in the advanced workstation condition.

What we see in comparing the computer conditions results for writing is a continuum: the earlier computer condition is the least advanced and the least efficient; the current pc condition is more advanced and efficient; and the advanced workstation as still more advanced and efficient. Gould's writers--using a line editor and poorer display--

wrote fewer words-per-minute than with paper. However, in the current study there was no difference in word-per-minute scores, even for the personal computer--with poor resolution but a display editor. Further, the advanced workstation actually surpasssed paper in words produced and time spent writing. In short, the important finding that emerges is that the advanced workstation *is* better than paper in these quantity measures--contrasted to the significant advantage for paper over the machine that Gould found in his study.

However, a slightly different picture emerges in the analysis of quality measures. Here is another marked instance where these results differed from Gould's: he found no difference in quality between the letters. However, the measures of quality were different in the two studies. Gould's raters simply chose the best essays from the group written by all writers and then Gould tallied the "votes" letters produced in each condition received. The raters in this study were 1)rating each writers essays against themselves, and 2) forced to place the letters into split quartile groups. Possibly, differences in letter quality did not show up because of the method of assigning quality that Gould used.

In the analyses of quality it is the pc and not hard copy that looks significantly different from the other conditions. In content, mechanics, and total quality the pc condition consistently has a significantly lower mean. Again the advanced display is significantly better (Neuman Keuls = $<.05$) than the pc, although the pen and paper condition is almost as good. These was no significant difference between the advanced workstation and pen and paper.

So in general, we see two trends: first, in quantity--amount of text produced-- the advanced machines are better than pen and paper, in marked contrast to the machine that Gould tested; second, the quality of writing produced is significantly poorer on the pc than on the advanced machine--in every quality measure, the pc came out on the bottom.

Conclusion

Let's return to the questions with which this paper began: we noted two different sets of claims--one that computers will help people write more and better, and the other--supported by Gould's early work--that machines do not lead to more or better writing. These seemingly contradictory claims can be reconciled if we elaborate them: *some* computers can help people write more and better, but *some* machines may also make them write more poorly.

Advances in machine design are encouraging--the poorer performance Gould found with computers seems to have turned, with more advanced machines, to a slight advantage for computers. However, this encouraging finding should be qualified in two important ways: the positive results come from a very advanced--and needless to say, expensive--machine, the kind of computer that most of us don't have access to. They are not even widely available at CMU, or "Computer U," as its sometimes called. We cannot assume--and indeed these results prohibit us from doing so--that the kind of computer typically used in education today will aid writers in the way that this workstation did in this study. be a boon to writers. (Lest I sound to negative, I acknowledge that many parts of the writing process and many kinds of writing can be greatly aided by the computer. In addition, many excellent word-processing programs and CAI programs may help writers and help teachers teach writing.) What I am advocating is restraint in assuming that because of the computers strengths, it be adopted whole and with little critical care by teachers of writing and writers. .

Second, the writers in this study are experienced, expert writers and computer users. All wrote regularly on the job; most had been using computers for at least 10 years; many had advanced degrees; and all were significantly older than most of our students. We should not be too hasty and extrapolate these findings to students--usually novice computer users, and often poor writers as well. Overall, the conclusion of these studies advocates CARE--there remains much to be done to determine when, where, with whom, and how computers can best aid writing.

Our own research will pursue examination of the processes of experienced computer users and writers, to determine first, if there are process differences which led to the quality differences demonstrated here. Second, these results, together with earlier reports of computer writers' conscious adaptation of their writing process into a "system" for computer writing, (see Haas and Hayes, 1986), lead to the hypothesis that these experienced computer writers have "learned" to write well on the machine. We plan to continue to explore just how computer writers utilize the strengths and adapt to the constraints of the computer when writing.

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ANOVA for Time to Compose

source	df	mean squares	F	prob.
Subjects	14	56.049		NS
Conditions	2	59.411	4.35	<.02
Subjects X Conditions	28	13.653		

Newman-Keuls Tests of Significance
for Time to Compose

	Advanced Workstation	PC	Pen and Paper
Advanced Workstation	———	2.40	4.178*
PC		———	1.18
Pen and Paper			———

*p<.05

ANOVA for Total Words Produced

source	df	mean square	F	prob.
Subjects	14	19292.49		NS
Conditions	2	30944.97	4.74	<.01
Subject X Condition	28	6528.48		

Newman-Keuls Tests of Significance
for Number of Words Produced

	Advanced Workstation	PC	Pen and Paper
Advanced Workstation	———	2.93	4.25*
PC		———	1.32
Pen and Paper			———

*$p < .05$

ANOVA for Content Quality

source	df	mean square	F	prob.
Subjects	14	.69286		NS
Conditions	2	14.61667	4.08	<.02
Subjects X Conditions	28	3.58095		

Newman-Keuls Tests of Significance
for Content Quality

	Advanced Workstation	Pen and Paper	PC
Advanced Workstation	_____	1.72	4.03*
Pen and Paper		_____	2.31
PC			_____

*p<.05

ANOVA for Total Quality

source	df	mean square	F	prob.
Subjects	14	3.3317		NS
Conditions	2	37.9556	4.28	<.02
Subject X Condition	28	8.8603		

Newman-Keuls Tests of Significance
for Total Quality

	Advanced Workstation	Pen and Paper	PC
Advanced Workstation	———	.52	3.828*
Pen and Paper		———	3.307**
PC			———

*p<.05
**p <.10